

Claims

1. A solid electrolyte comprising an inorganic substance comprising
5 a lithium ion conductive crystalline and being substantially free of
an organic substance and an electrolytic solution.
2. A solid electrolyte as defined in claim 1 wherein the inorganic
substance comprising a lithium ion conductive crystalline is
10 substantially free of a pore or a crystal grain boundary which
obstructs ion conduction.
3. A solid electrolyte as defined in claim 1 wherein the inorganic
substance comprising a lithium ion conductive crystalline is
15 lithium ion conductive glass-ceramics.
4. A solid electrolyte as defined in claim 1 comprising an inorganic
substance powder comprising a lithium ion conductive crystalline
and an inorganic substance comprising Li.
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5. A solid electrolyte as defined in claim 4 wherein the inorganic
substance powder comprising a lithium ion conductive crystalline
has ion conductivity of 10^{-4}Scm^{-1} or over, has an average particle
diameter of $9 \mu \text{m}$ or below, and is contained in the solid electrolyte
25 in an amount within a range from 50 mass% to 95 mass%.
6. A solid electrolyte as defined in claim 3 wherein the ion
conductive glass-ceramics are in the form of a thin plate.
- 30 7. A solid electrolyte as defined in claim 6 wherein the lithium ion
conductive glass-ceramics have a thickness within a range from $15 \mu \text{m}$
to $200 \mu \text{m}$.
8. A solid electrolyte as defined in claim 1 having ion conductivity
35 which is 10^{-5}Scm^{-1} or over.

9. A solid electrolyte as defined in claim 1 wherein the inorganic substance comprising a lithium ion conductive crystalline has a predominant crystal phase of $\text{Li}_{1+x+y}\text{Al}_x\text{Ti}_{2-x}\text{Si}_y\text{P}_{3-y}\text{O}_{12}$ where $0 \leq x \leq 1$ and $0 \leq y \leq 1$.

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10. A solid electrolyte as defined in claim 1 wherein the inorganic substance comprising a lithium ion conductive crystalline comprises, in mol %;

	Li_2O	12 - 18%
10	$\text{Al}_2\text{O}_3 + \text{Ga}_2\text{O}_3$	5 - 10%
	$\text{TiO}_2 + \text{GeO}_2$	35 - 45%
	SiO_2	1 - 10% and
	P_2O_5	30 - 40%.

15 11. A solid electrolyte as defined in claim 1 wherein the inorganic substance comprising a lithium ion conductive crystalline comprises, in mass %;

	Li_2O	3 - 10%
	$\text{Al}_2\text{O}_3 + \text{Ga}_2\text{O}_3$	5 - 20%
20	$\text{TiO}_2 + \text{GeO}_2$	25 - 40%
	SiO_2	0.5 - 8% and
	P_2O_5	40 - 55%.

25 12. A lithium ion secondary battery comprising a solid electrolyte as defined in any of claims 1 - 11.

30 13. A lithium ion secondary battery as defined in claim 12 comprising an inorganic substance comprising a lithium ion conductive crystalline in a positive electrode and/or a negative electrode.

35 14. A lithium ion secondary battery as defined in claim 13 wherein the inorganic substance comprising a lithium ion conductive crystalline contained in the positive electrode and/or the negative electrode is substantially free of a pore or a crystal grain boundary which obstructs ion conduction.

15. A lithium ion secondary battery as defined in claim 13 wherein the inorganic substance comprising a lithium ion conductive crystalline contained in the positive electrode and/or the negative electrode is a lithium ion conductive glass-ceramics.

16. A lithium ion secondary battery as defined in claim 13 wherein an average particle diameter of the inorganic substance comprising a lithium ion conductive crystalline contained in the positive electrode and/or the negative electrode is 1/5 or below of an average particle diameter of an active material of the positive electrode and/or the negative electrode comprising an inorganic substance comprising a lithium ion conductive crystalline.

17. A lithium ion secondary battery as defined in claim 13 wherein an amount of the inorganic substance comprising a lithium ion conductive crystalline contained in the positive electrode and/or the negative electrode is 2 – 35 mass % of an active material of the positive electrode and/or the negative electrode.

18. A lithium ion secondary battery as defined in claim 13 wherein the inorganic substance comprising a lithium ion conductive crystalline contained in the positive electrode and/or the negative electrode comprises, in mol %;

Li_2O	12 – 18%
$\text{Al}_2\text{O}_3 + \text{Ga}_2\text{O}_3$	5 – 10%
$\text{TiO}_2 + \text{GeO}_2$	35 – 45%
SiO_2	1 – 10% and
P_2O_5	30 – 40%.

19. A lithium ion secondary battery as defined in claim 13 wherein the inorganic substance comprising a lithium ion conductive crystalline contained in the positive electrode and/or the negative electrode comprises, in mass %;

Li_2O	3 – 10%
$\text{Al}_2\text{O}_3 + \text{Ga}_2\text{O}_3$	5 – 20%

TiO ₂ + GeO ₂	25 - 40%
SiO ₂	0.5 - 8% and
P ₂ O ₅	40 - 55%.

- 5 20. A lithium ion secondary battery as defined in claim 13 wherein the inorganic substance comprising a lithium ion conductive crystalline contained in the positive electrode and/or the negative electrode has a predominant crystal phase of Li_{1+x+y}Al_xTi_{2-x}Si_yP_{3-y}O₁₂ where $0 \leq x \leq 1$ and $0 \leq y \leq 1$.
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21. A lithium ion secondary battery as defined in any of claims 13 - 17 which comprises, in the positive electrode and/or the negative electrode, the same inorganic substance as the inorganic substance comprising a lithium ion conductive crystalline contained in the
- 15 solid electrolyte.